

# *Regional Climate Simulations within Ouranos*

**Daniel Caya**

*Directeur, Simulations climatiques*

- The Ouranos Consortium
- Regional Climate Simulations
- First results
- Planned activities 2004 - 2009



*Consortium sur la climatologie  
régionale et  
l'adaptation aux changements  
climatiques*

# **The Ouranos Consortium : Unique in Canada**



550 Sherbrooke West  
Montréal  
(near UQÀM, McGill, INRS, HQ ...) 18<sup>th</sup> and 19<sup>th</sup> floors, 1800 m<sup>2</sup>

- Coordination of interdisciplinary research
- 90 scientists and professionals working together at the same location
- Access to an extensive network of experts, users and true stakeholders
- Dedicated supercomputer for climate simulations:
  - SGI-3600: 32 CPU
  - CRAY SX-6: > 0,1 TFLOPS sustained (early 2004)
  - 125 Tbytes storage
- 6 M\$ annual base budget (13 M\$ with leverage)



**More than 150 scientists at work on 14 programs, 45 projects in:**

- Climate Science
- Support to Adaptation Decision



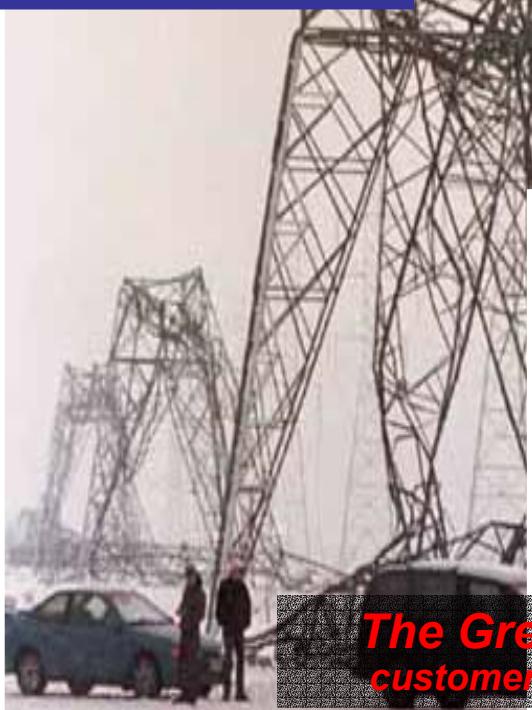
# The "Quebec" Climate



**large tides and storms**



**Saguenay (1996),  
26 millions m<sup>3</sup> of water  
and 9 millions tons of debris**



© La Maison de La Presse, Chicoutimi



**floods**



**forest fires**



**droughts, heat spells**

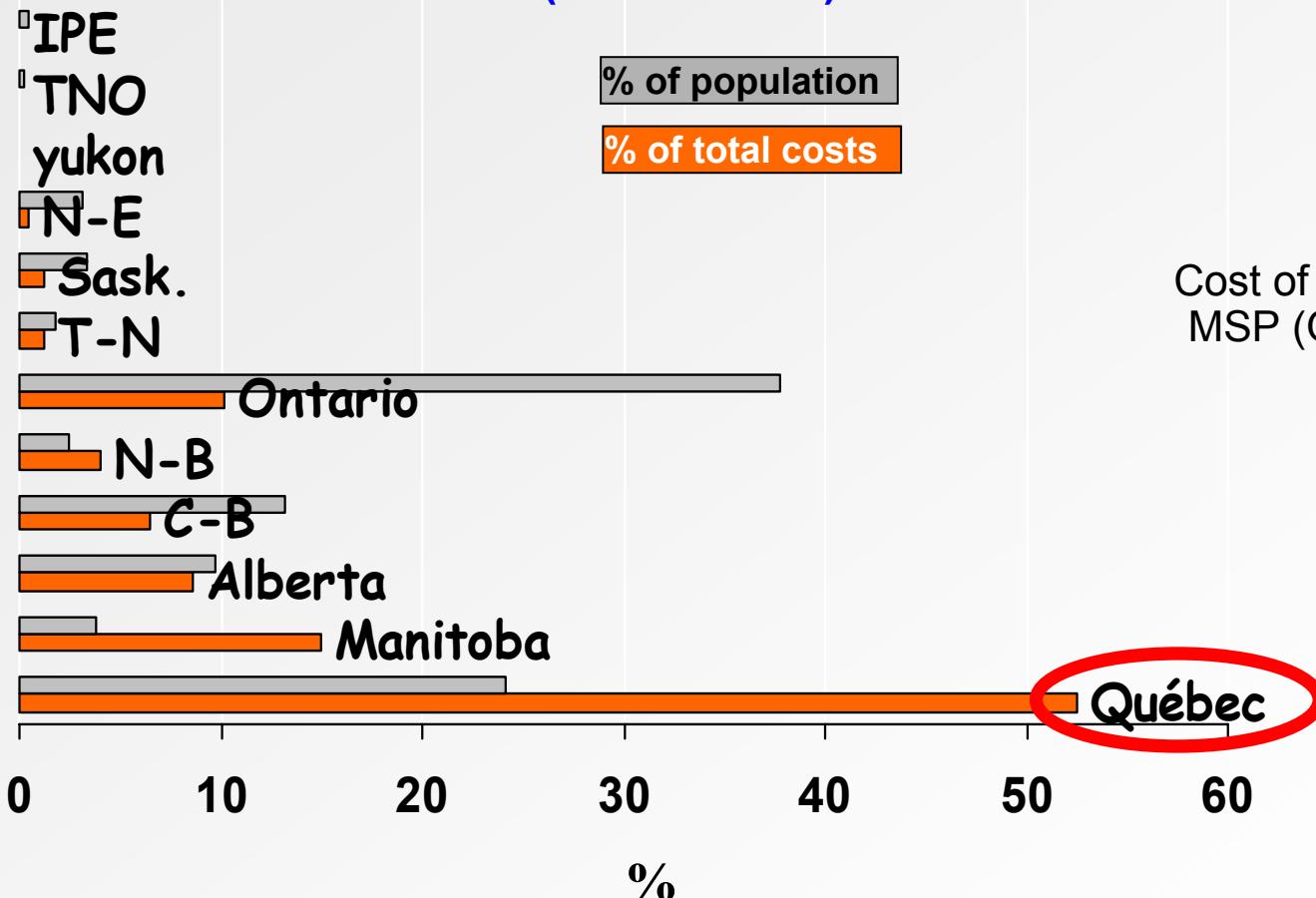


**The Great Ice Storm (1998), 1.5 millions customers without electricity for up to 30 days**

# *Increasing Costs of Extreme Weather ?*



## Costs of disasters (federal transfer) compared to populations (1970 – 1999)



Cost of disasters paid for by  
MSP (Québec) since 1982



# Québec Priorities in Adaptation



## Arctic:

- **Permafrost**

(infrastructures,  
housing,  
livelihood)

## Considerations :

- Economy
- Population:  
health and safety
- Environment and  
conservation
- System dynamics

- Reference scenarios on climate  
and socio-economics  
(for all sub-regions)

## Resources:

(sustainable development)

- **Hydroelectricity**
- **Forestry**

## St-Lawrence Valley:

- **Urban environment**
- **Rural environment**

## Social and Environmental Issues:

- Health in urban environment
- Impacts of extremes
- Drinking water supply
- Ecosystems and biodiversity

## Maritimes:

- **Coastal Erosion**
- Fisheries

## Economic Issues:

- Conflicts between users for the  
water in the St-Lawrence
- Water management
- Agriculture, agri-food,
- Transportation
- Energy demand profile
- Tourism

# La programmation d'Ouranos en 2004



## La science du climat

### Données historiques

- archives, validation, accès
- données dérivées

### Modélisation climat: recherche

- modèle régional
- couplage Baie d'Hudson

### Simulations climat

- développement
- production, analyse

Temps violent, Variabilité naturelle

Analyses statistiques

scénarios climatiques, socio-économiques

### Analyse du climat

- Scénarios climat
- Mise à l'échelle statistique
- Analyse statistique
- Temps violent
- Régime de temps

## Les 10 grands programmes à Ouranos

## Impacts et stratégies d'Adaptation par régions

### Nordique

- Pergélisol et transport
- Pergélisol et communauté
- Accessibilité du territoire

### Forêts

- Production
- Feux
- Dommages par extrêmes

### St-Laurent fluvial

- Évaluation niveaux d'eau
- Outaouais
- Sédiments tributaires
- Impacts: biophysique, économique
- Stratégies d'adaptation

### Hydroélectricité

- Tourbières
- Variabilité naturelle
- Hydraulicité
- Utilisation des simulations climat

### Maritimes

- Érosion côtières sur 3 zones témoins

### Sud du Québec

- Eau : potable, drainage urbain, design-fortes pluies
- Bassin Châteauguay: nappe phréatique, crues, ...
- Agroalimentaire: économique, impacts des extrêmes
- Santé: allergies-canicules, santé urbaine
- Tourisme ski-golf

## Information pour les décideurs

Intégration des connaissances

Evaluation des impacts

Stratégies d'adaptation, opportunités économiques

Québec

Hydro Québec

Environnement Canada Environment Canada

UQÀM

Université du Québec à Montréal

McGill

UNIVERSITÉ  
LAVAL

Université du Québec  
Institut national de la recherche scientifique

# **Canada's Ouranos: Consortium on regional climate and adaptation to climate changes**

**<http://www.ouranos.ca/>**

- Created May 2002 by:
  - Government of the Province of Québec
  - Hydro-Québec (hydro-electric power utility)
  - Meteorological Service of Canada
  - Participating Québec Universities

**MISSION:** “Advance the understanding of the issues and the associated requirements for adaptation resulting from climate change on the scale of the North American continent”

# **Ouranos:**

## **Consortium on regional climate and adaptation to climate changes**

<http://www.ouranos.ca/>

- Mission of Ouranos:
  - To generate “regional” scenarios for the evolution of the climate and its expected impacts, and to make them available to the decision-maker partners of Ouranos.
  - To develop expertise and strategies so as to mitigate the impact of climate change and to capitalize on potential economic benefits

# Ouranos

<http://www.ouranos.ca/>

- To promote the acquisition of expertise that will advance the understanding of regional climate change and of its environmental, social, and economic impacts
- To develop and adapt the tools necessary for providing decision makers with detailed climate change scenarios on a regional scale
- To performs evaluations of expected sectorial impacts in order to optimize adaptation strategies.

# Ouranos

<http://www.ouranos.ca/>

- Participates in the construction of historical climate databases
- Supports the development of the Canadian Regional Climate Model (CRCM)
- Runs climate simulations on the geographic scales required for various impact and adaptation studies
- Analyses various phenomena connected to statistical variability
- Develop detailed medium and long term scenarios of the evolution of the Québec climate
- Determine the principal vulnerabilities of different regions and sectors in Québec, in terms of the physical environment and of the impact on humans and the economy
- Helps to establish priority areas of intervention and develop adaptation strategies to mitigate the impacts or to capitalize on economic opportunities

# Réseau canadien de Modélisation Régionale du Climat (Réseau MRCC)

**Canadian Network for  
Regional Climate Modelling  
(CRCM Network)**

René Laprise  
Principal Investigator

Professeur, Université du Québec à Montréal (UQÀM)

27 octobre 2003

# Co-Is of CRCM Network

## UQÀM:

Blanchet Jean-Pierre  
Girard Éric  
Laprise René  
Larocque Marie

Aerosols, Radiation, Arctic climate  
Arctic and Clouds microphysics  
Num. methods, climate modelling  
Hydrological processes

## Ouranos:

Caya Daniel  
Slivitzky Michel

Regional climate modelling  
Hydrology and climate variability

## IML/DFO - UQÀR Rimouski:

Saucier François

Regional Ocean Modelling

## CCCma/MSC Victoria:

Boer George  
McFarlane Norman  
Zwiers Francis

Climate Diagnostic, O-A coupling  
Physical param. in climate models  
Climate and Statistical Analysis

## RPN/MSC Dorval:

Brunet Gilbert  
Côté Jean

Weather prediction, diagnostics  
Variable Resolution modelling

# **CRCM Network**

# **Scientific Research Plan**

# **2003 - 2006**

## **3 main themes:**

1. Diagnostics and budget studies
2. Dynamical downscaling approaches
3. Development of the CRCM system

# 1. Diagnostics and budget studies

## 1.1 Scale-selective diagnostic budget studies

Laprise, Boer and Caya

PDF Soline Bielli

PhD Leticia Hernández-Díaz

## 1.2 A Decadal-scale Canadian experiment

Caya and Laprise

PDF Yanjun Jiao

PhD Biljana Music

## 1.3 Regional-Scale Seasonal Prediction Project (with GEM-VR)

Brunet, Laprise, Caya and Zwiers

PhD Hatem Yazidi

## 1.4 Atmospheric Models Intercomparison Project (AMIP-II, SGMIP) (with GEM-VR)

Côté, Laprise and Caya

RA Katja Winger

1 Graduate Student

## 1.5 Arctic Model Intercomparison Project (ARCMIP, GLIMPSE)

Girard, Blanchet, McFarlane, Laprise and Caya

RA Rong-Ming Hu

MSc Biljana Bekcic

## 1.6 Project to Intercompare Regional Climate Simulations (PIRCS 1c & 2)

Caya, Laprise and Côté

MSc Bertin Ossonon

## **2. Dynamical downscaling approaches**

### **2.1 Big-Brother Experiment**

Laprise and Caya

PhD Milena Dimitrijevic

### **2.2 Influence of surface forcing and large-scale nudging on RCM internal variability**

Caya and Laprise

PhD Philippe Lucas-Picher

### **2.3 Internal variability of RCM in ensemble simulations**

Laprise and Caya

PDF Ramón de Elía

### 3. Development and improvements in the CRCM

#### 3.1 Regional Ocean Coupling

Saucier, Caya, Laprise and Boer

1/3 RA Simon Senneville

PDF Minwei Qian

2 Graduate Students

#### 3.2 River-routing and surface water processes

Caya, Slivitzky, Larocque, Laprise and Saucier

PDF Laxmi Sushama

1 Graduate Student

#### 3.3 Physical parameterisation including land-surface processes ([CRCM\\_4](#))

Laprise, Caya and McFarlane

RA Arturo Quintanar

1 Graduate Student

#### 3.4 Computer code parallelisation ([CRCM\\_5](#))

Laprise, Côté, Zwiers and Caya

1 Research Assistant

1 Graduate Student

# ***Simulations climatiques régionales à Ouranos***

**Daniel Caya**

*Directeur, Simulations climatiques*

1<sup>er</sup> Symposium Ouranos  
Montréal, 9 et 10 juin 2004

- Programme Simulations climatiques
- Activités 2003 - 2004
  - Simulations complétées
- Programme d'activités 2004 - 2006



*Consortium sur la climatologie régionale et l'adaptation aux changements climatiques*

# Mandate for the team

## *Simulations climatiques*

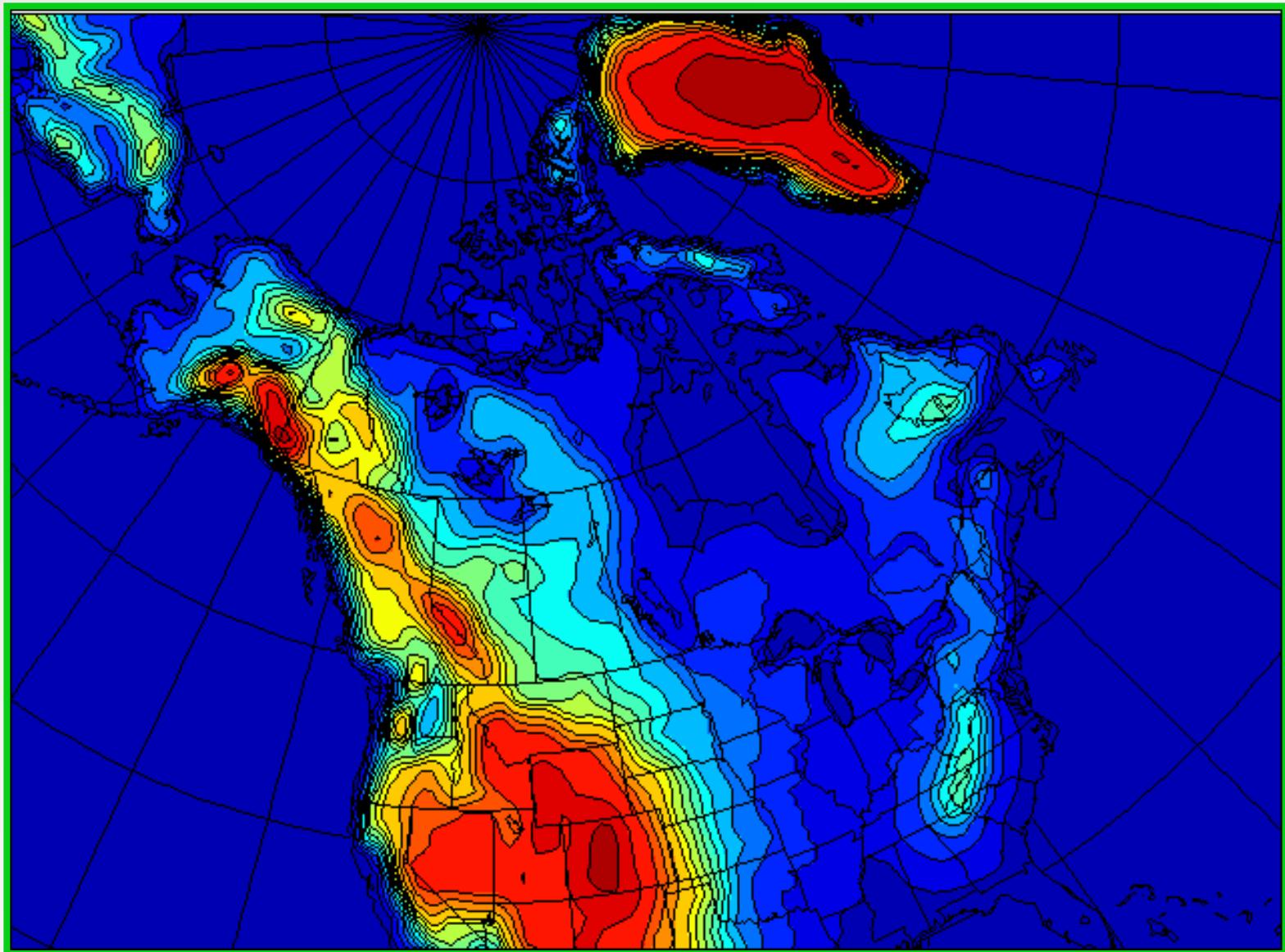
- Supply Ouranos' partners with reliable regional climate projections
- Evaluation of the uncertainties associated to the projections
- Help impacts and adaptation scientists in the use of the projections

# Équipe Simulations

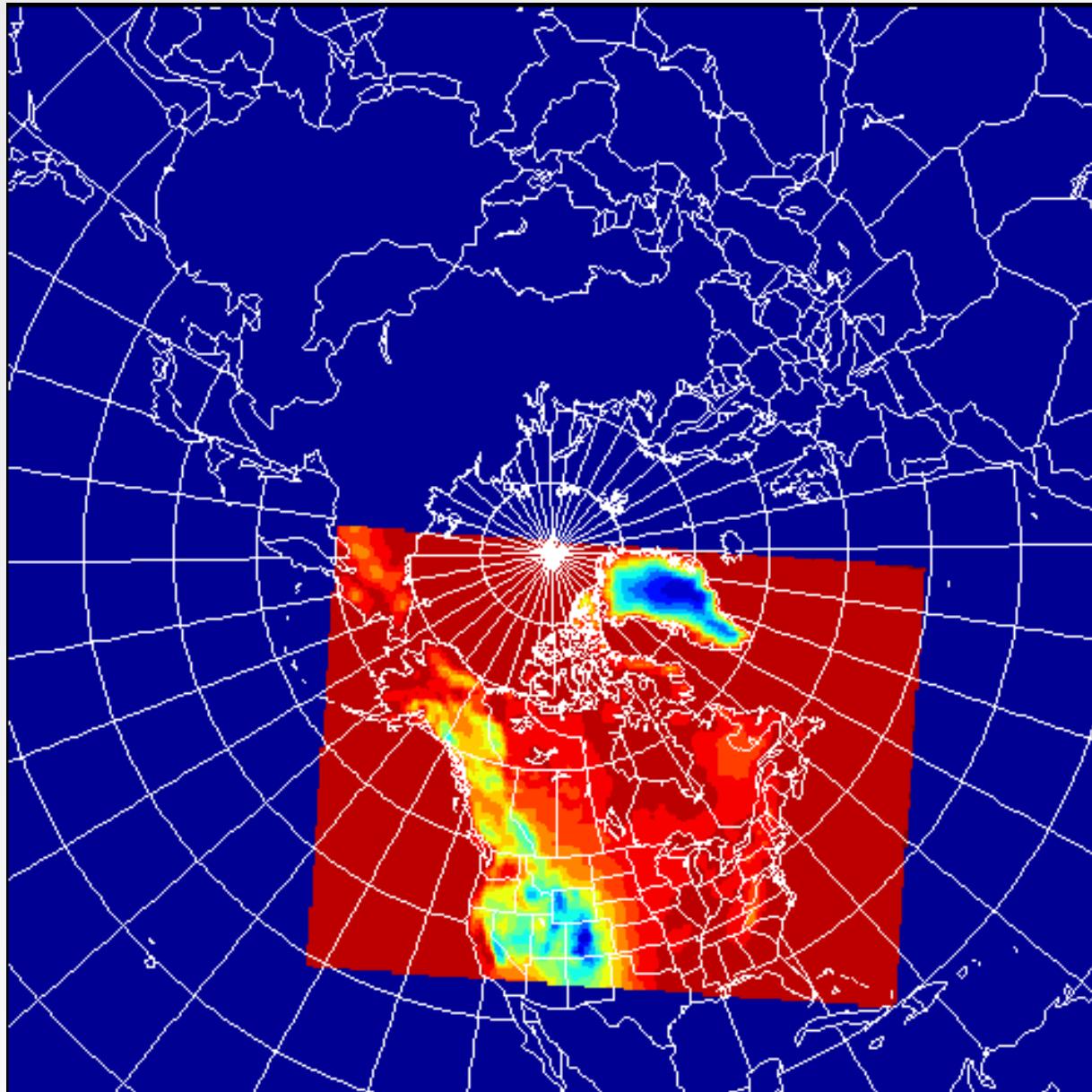
## Objectives for year 1 (2003)

- Make an operational environment for CRCM
- Define an integration domain compatible with Ouranos needs
- Generate the first climate projections over Québec and Canada
- Evaluation of the simulations

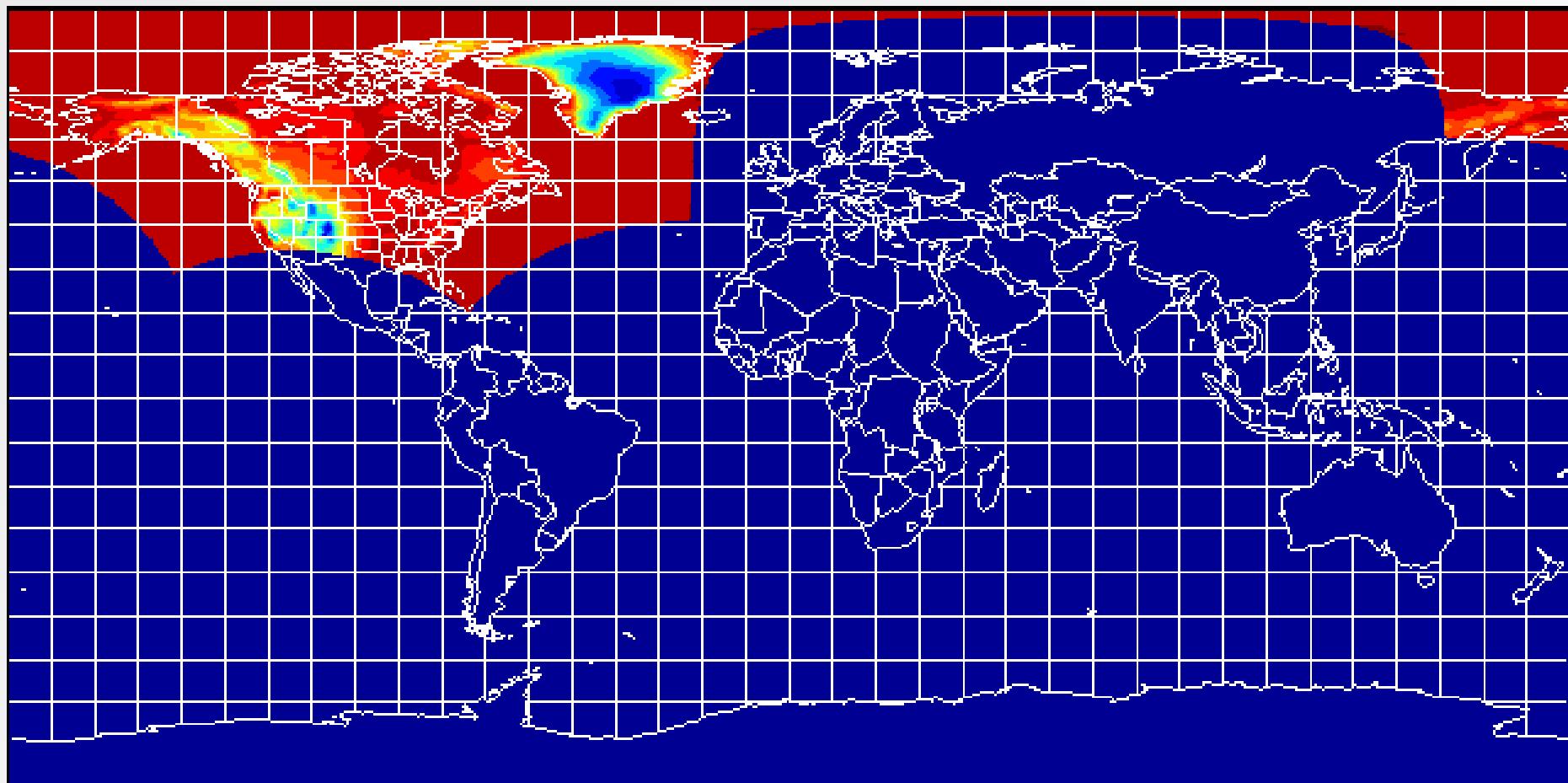
# Le domaine MRCC pour Ouranos



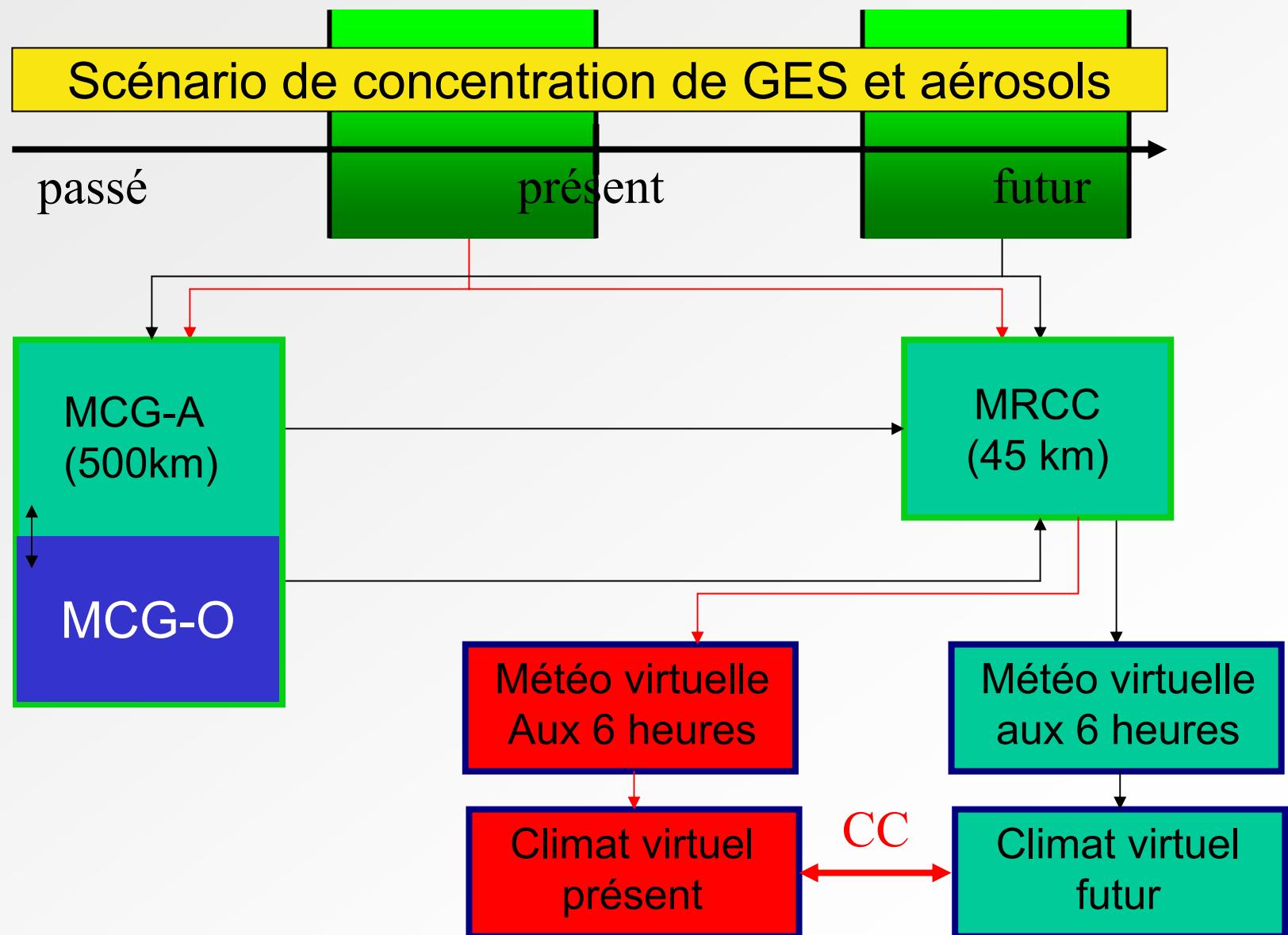
# Le domaine PCAN

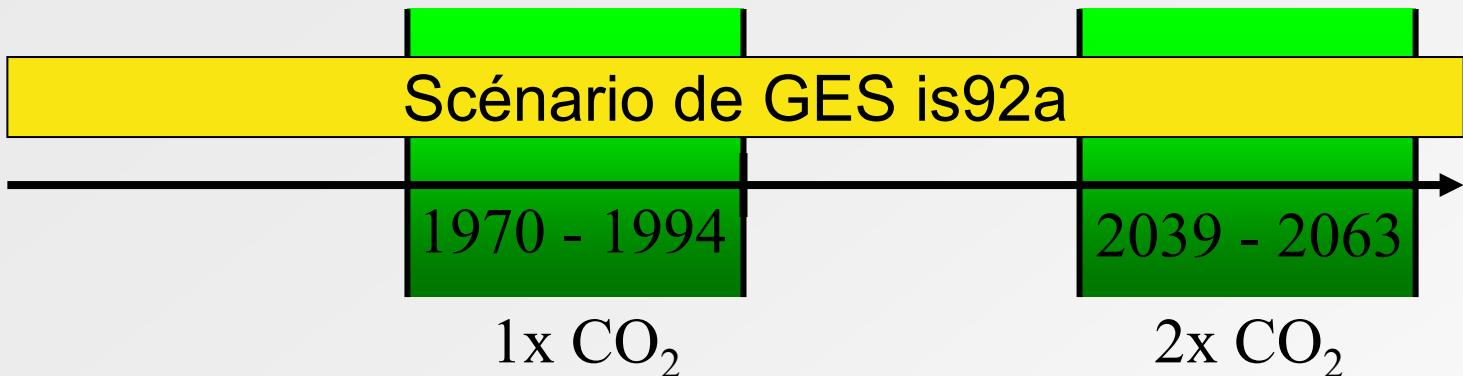


# Le domaine PCAN



# Système de modélisation régionale du climat



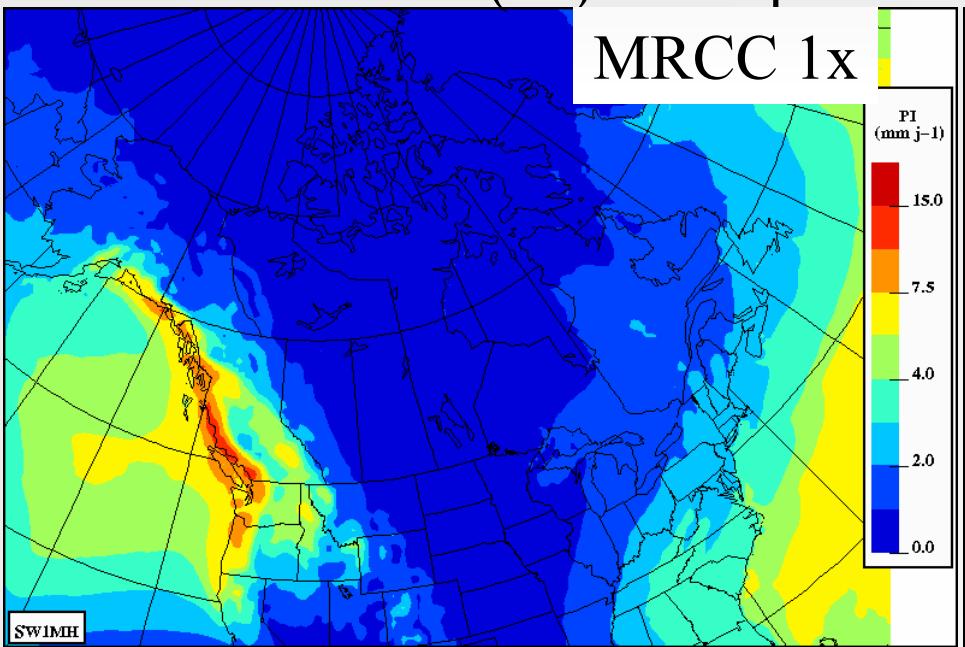


## Résultats - Projection climatique précipitation, température, neige au sol

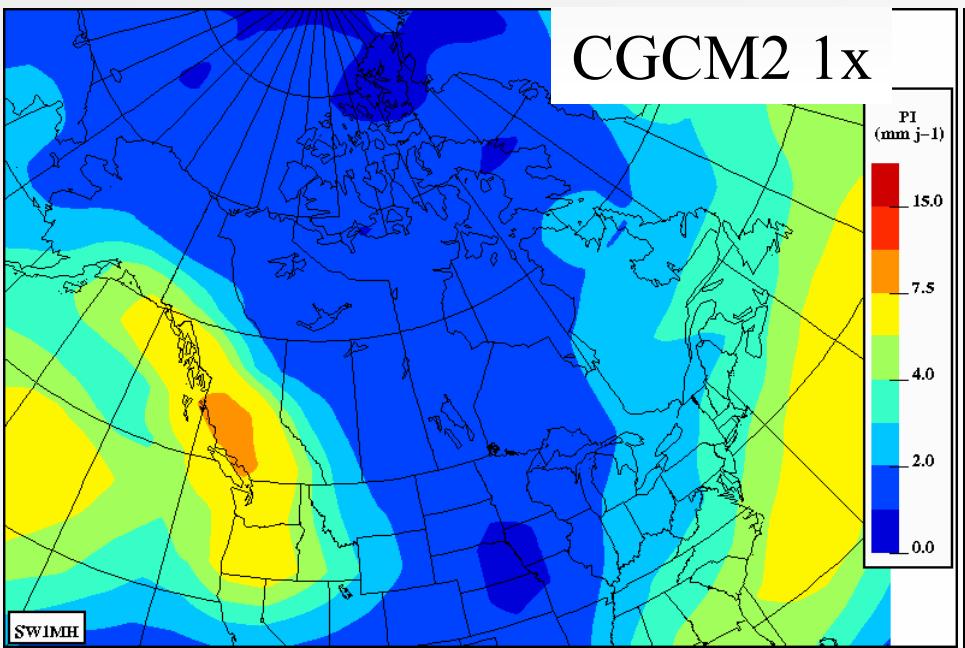
MRCC piloté par CGCM2 (is92a)  
CGCM2 is92a

Climat actuel (1x) Précipitation hiver (DJF) Climat futur (2x)

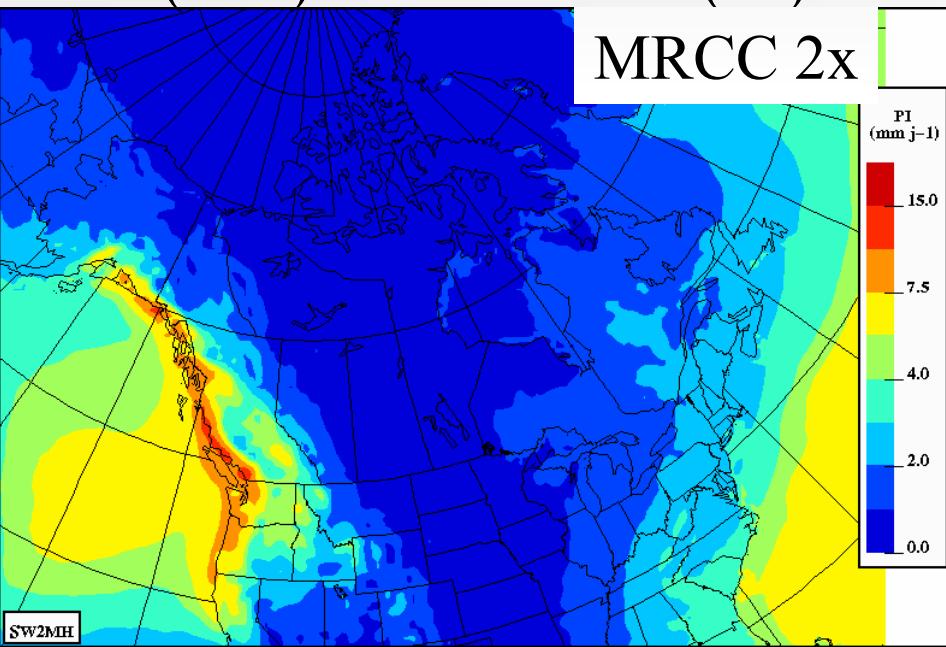
MRCC 1x



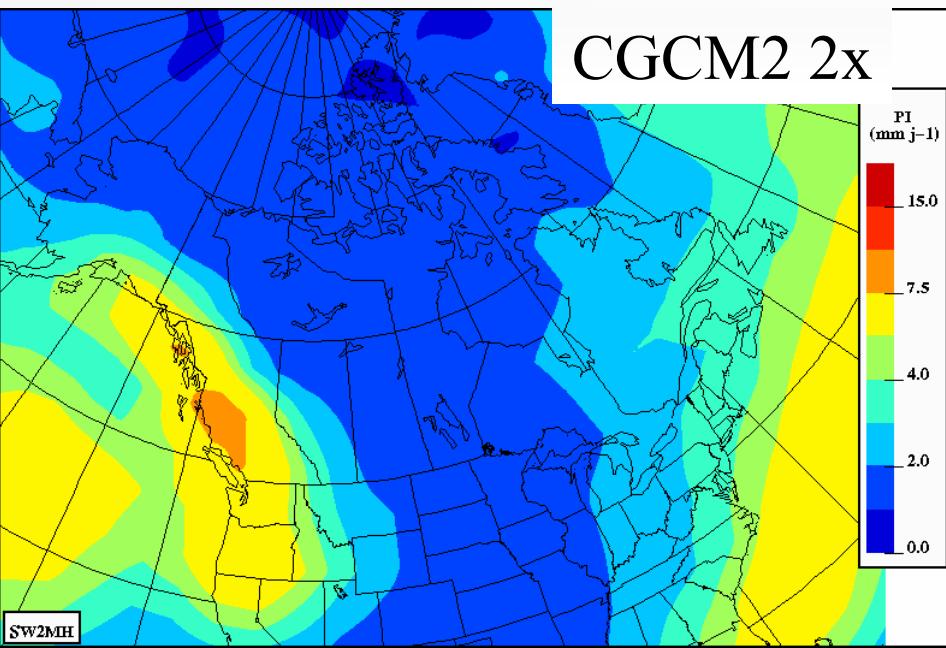
CGCM2 1x



MRCC 2x



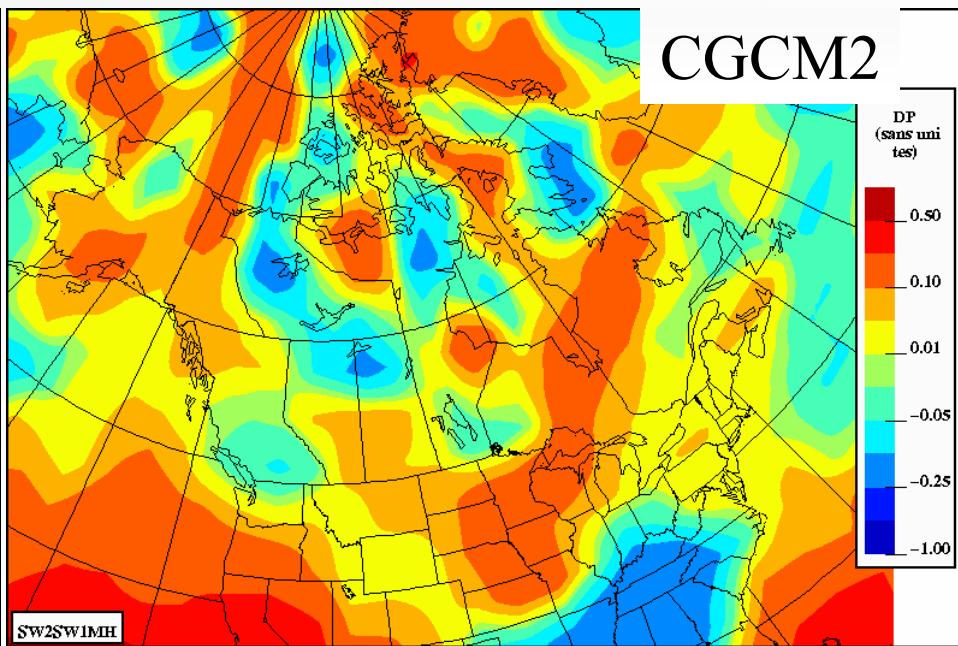
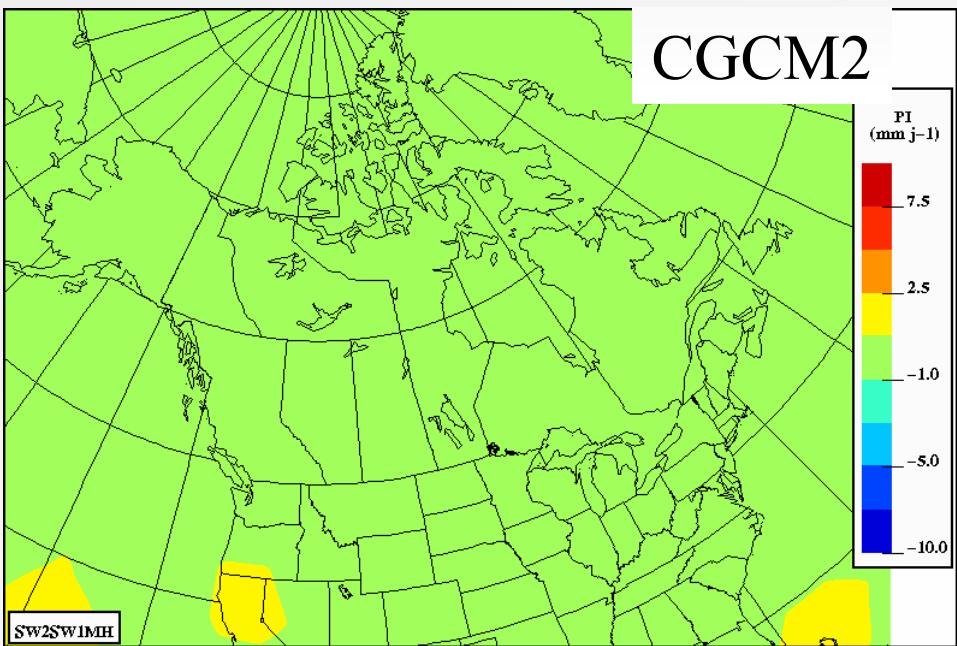
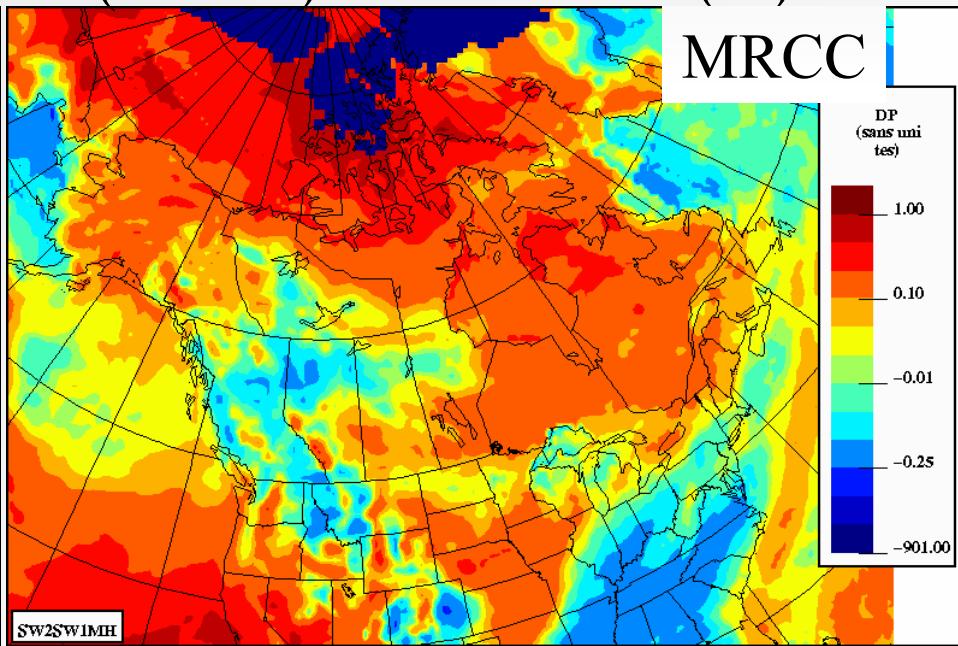
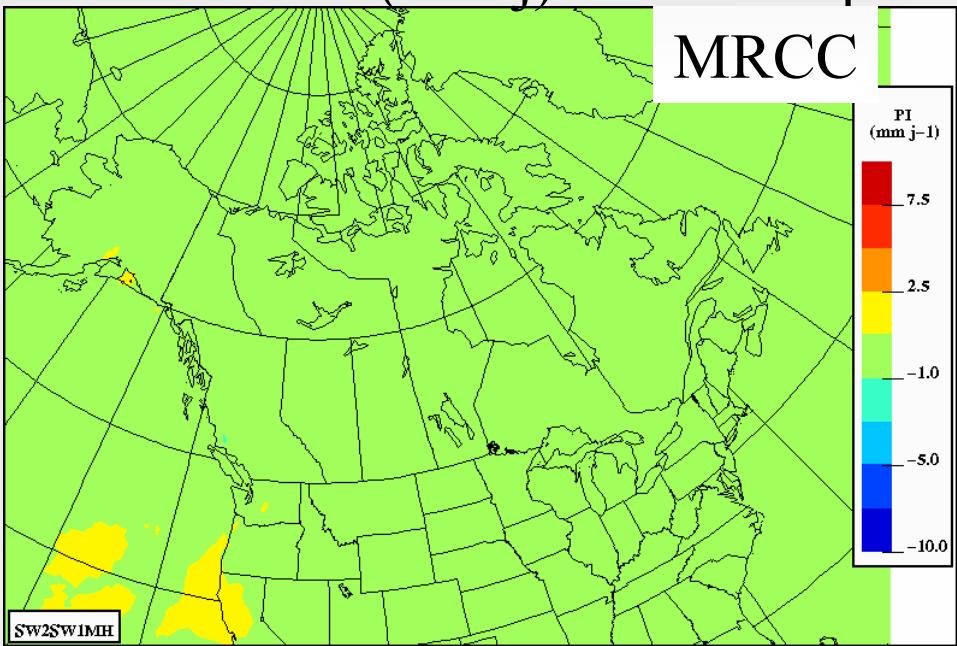
CGCM2 2x



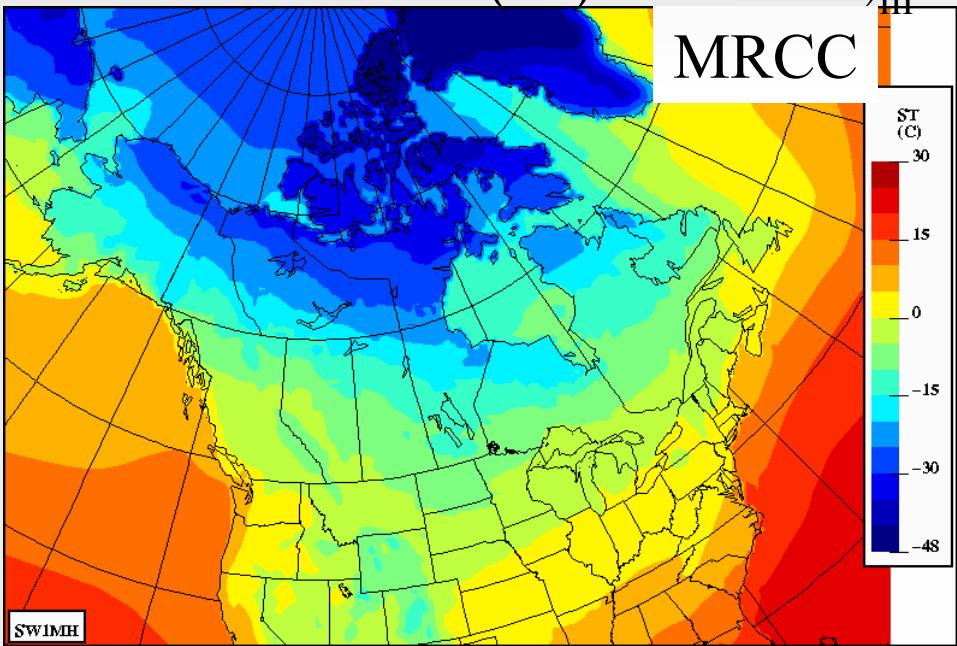
SW1MH

SW2MH

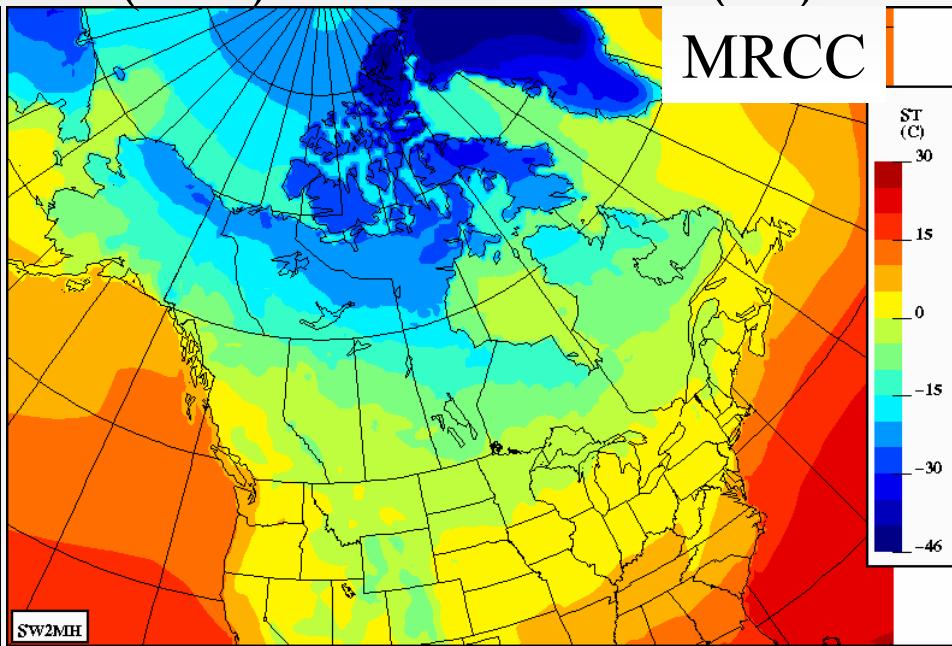
# Absolu (mm/j) Delta Précipitation (2x - 1x) DJF Relatif (%)



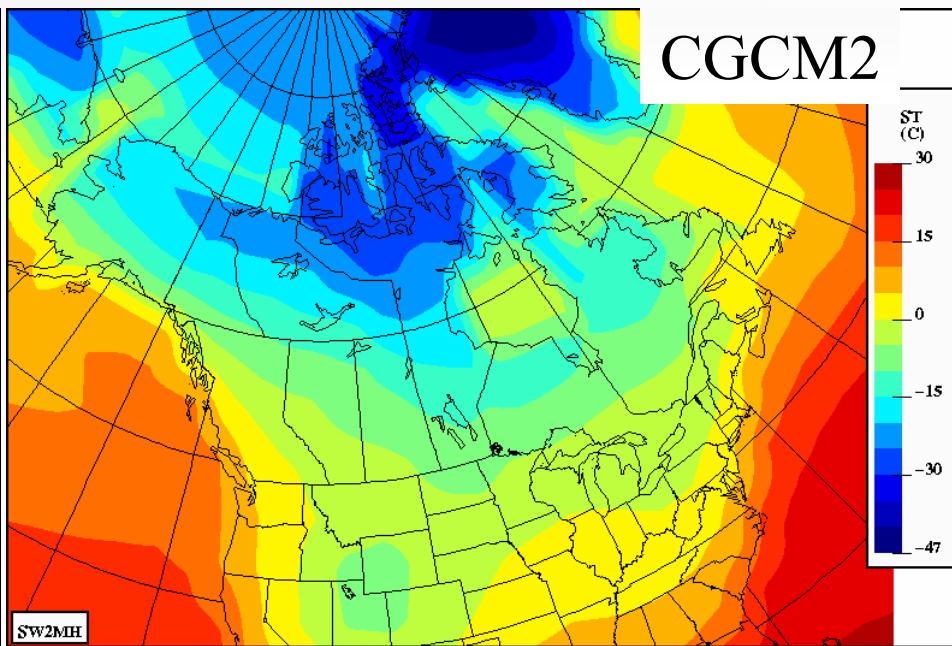
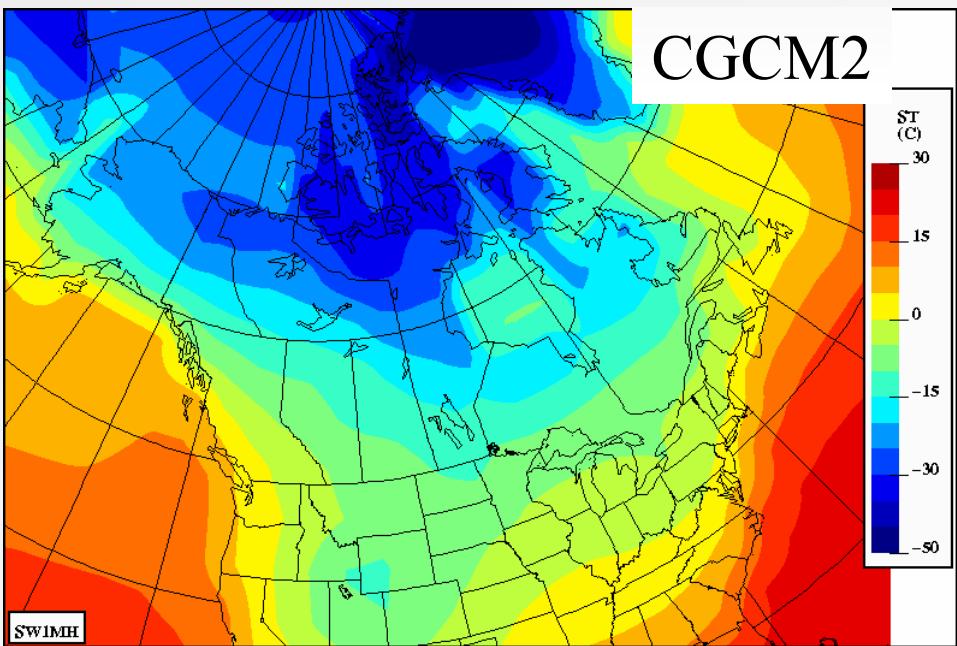
Climat actuel (1x)



TEMP<sub>2m</sub> hiver (DJF)



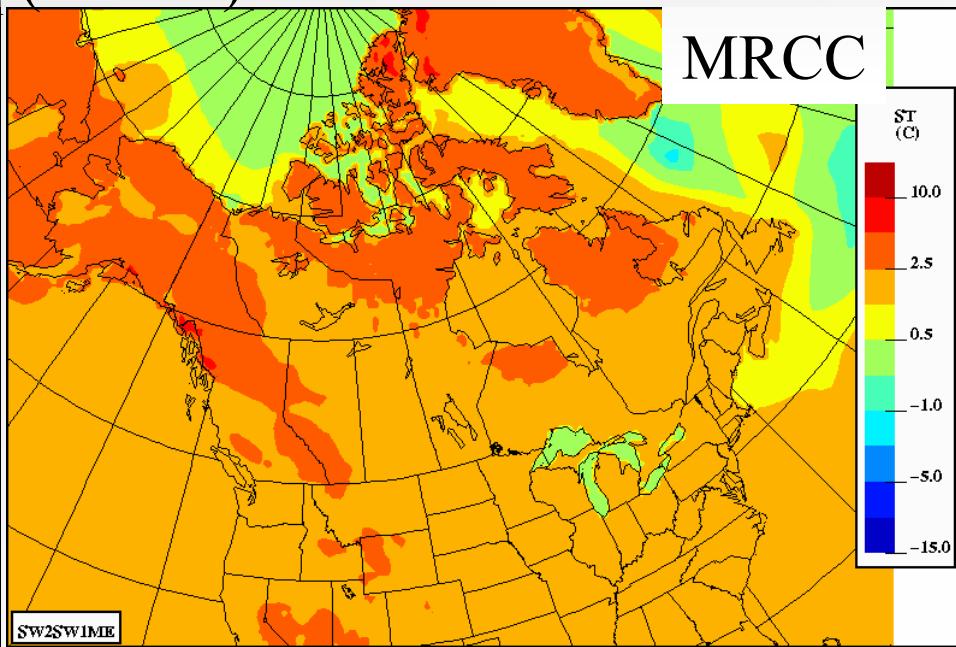
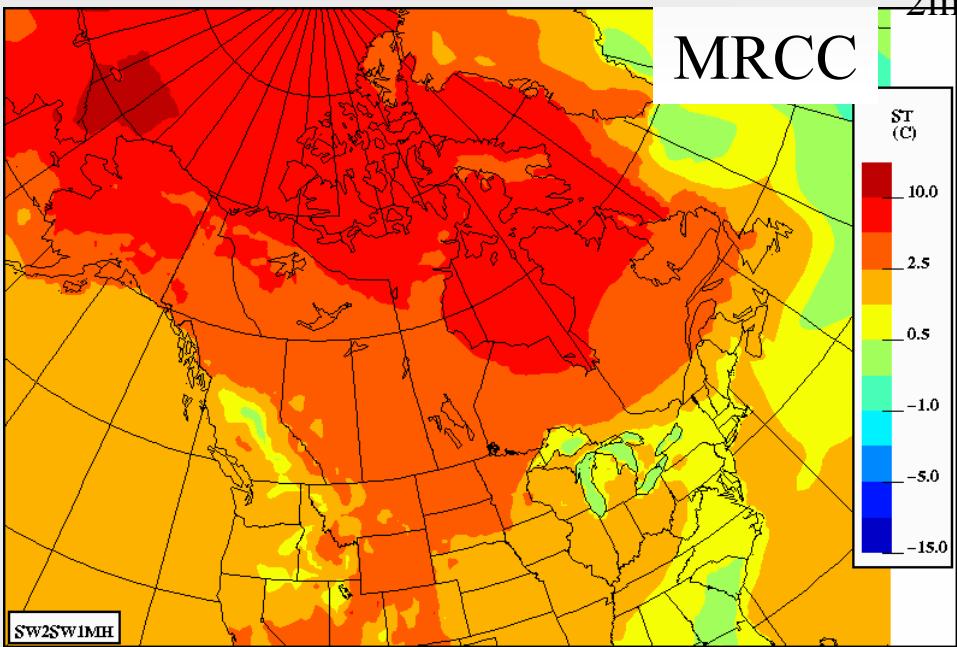
CGCM2



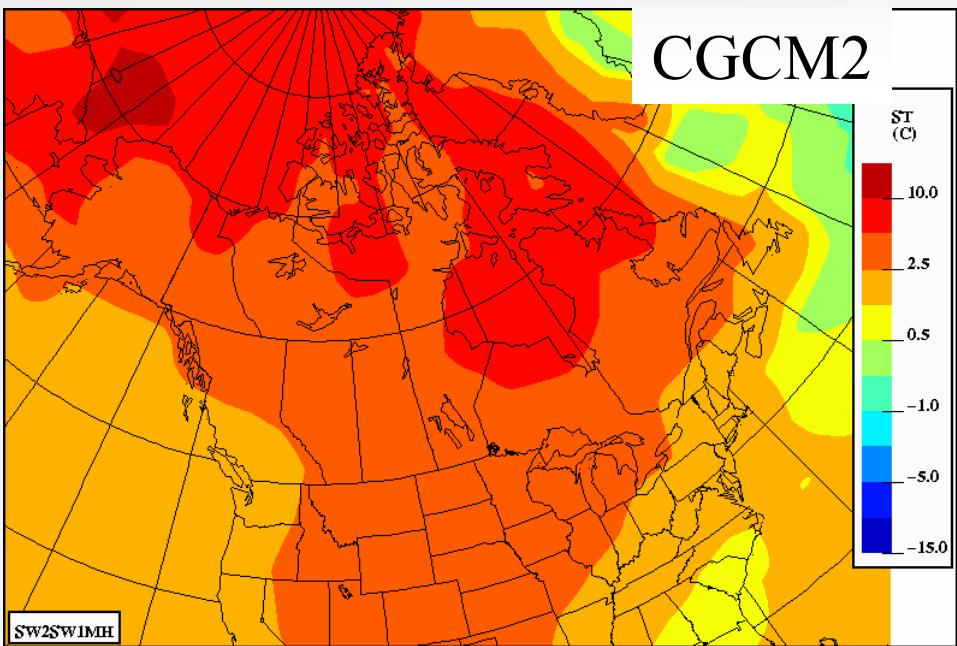
DJF

Delta  $T_{2m}$  ( $2x - 1x$ )  
MRCC

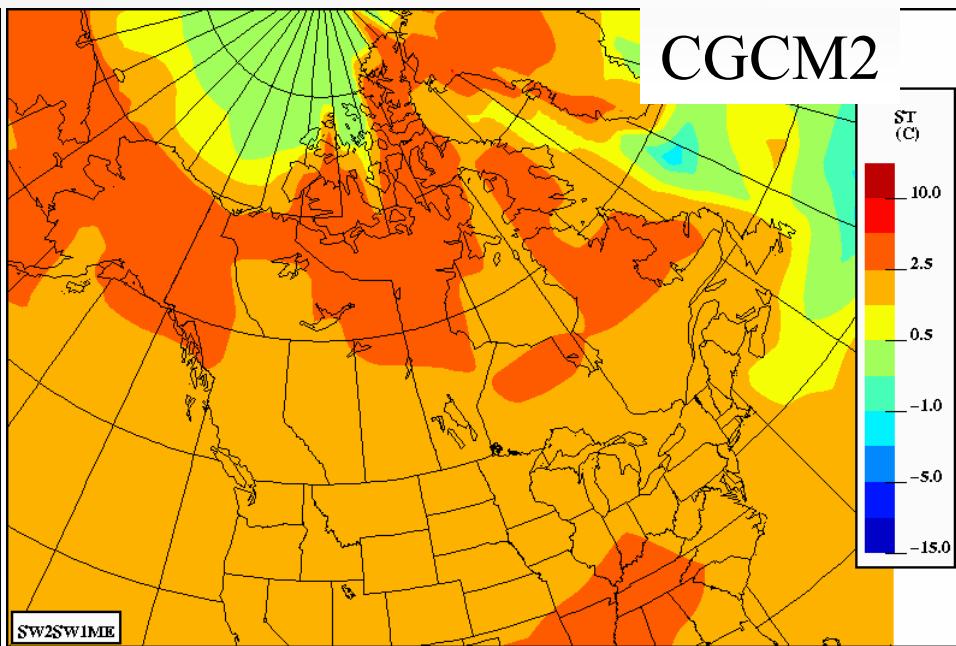
JJA



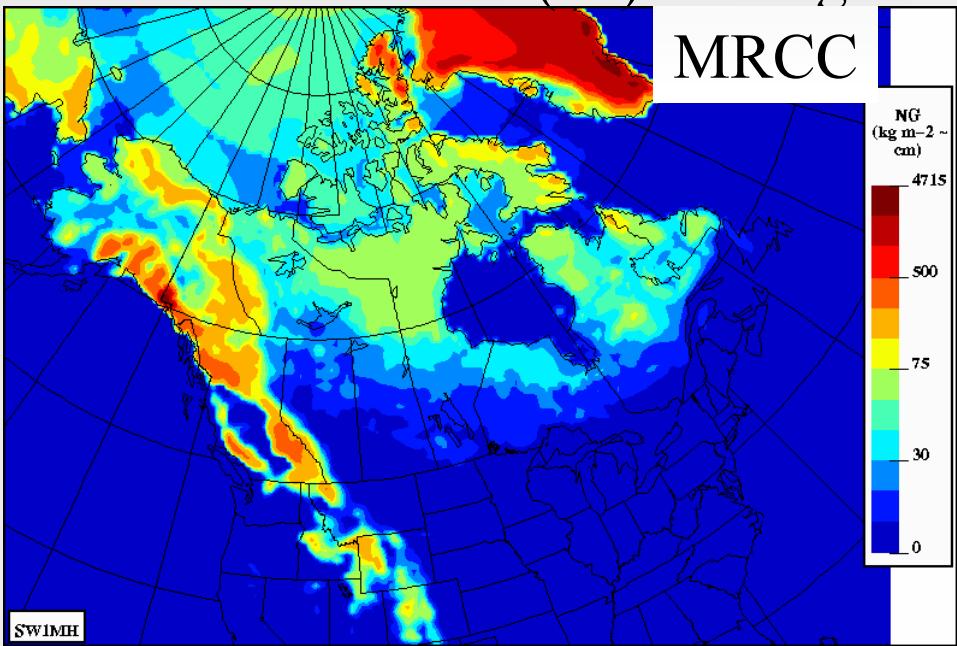
CGCM2



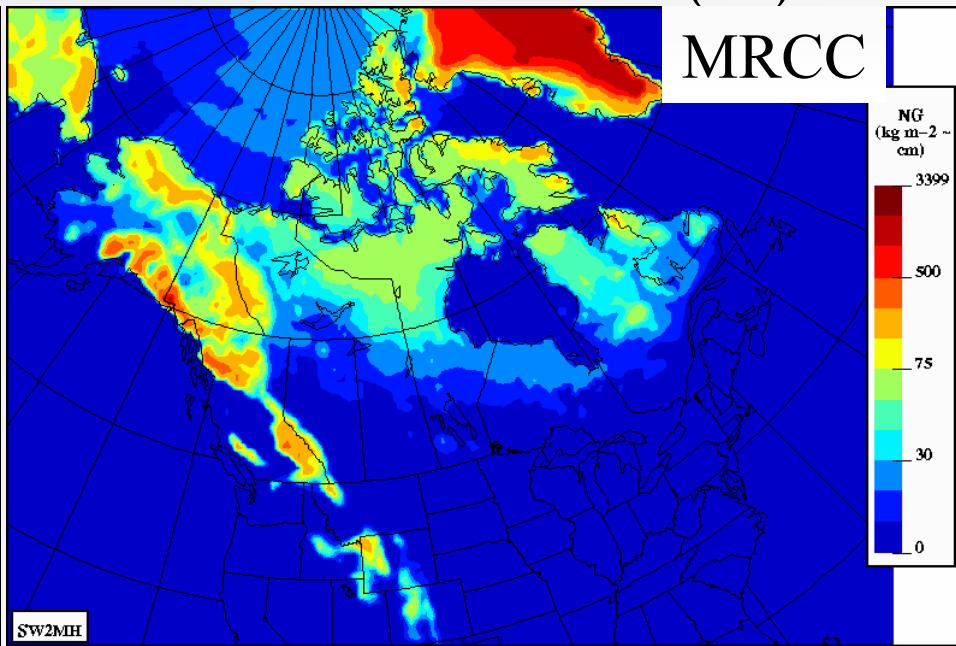
CGCM2



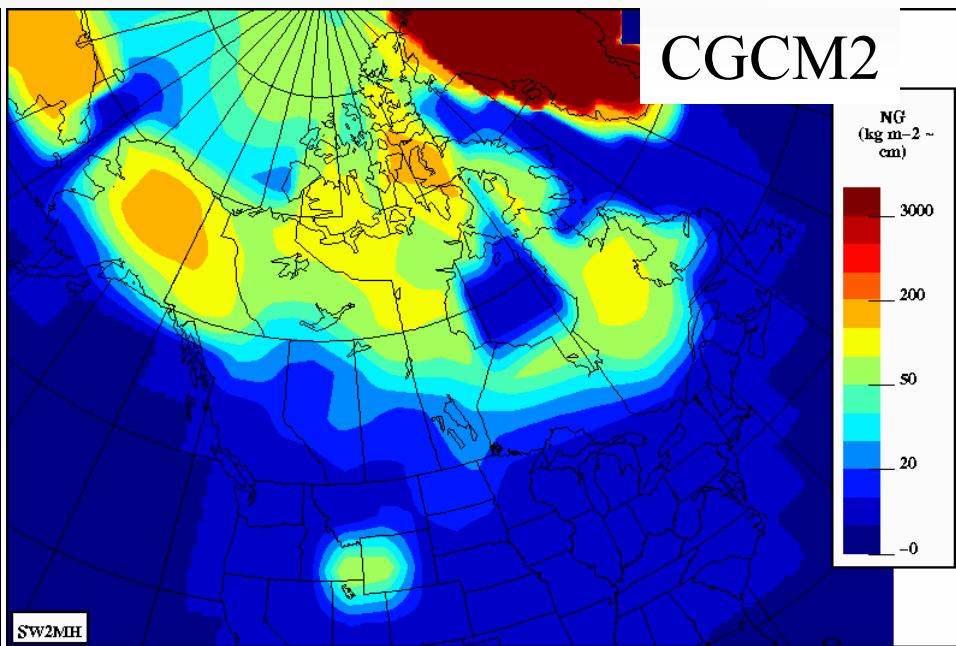
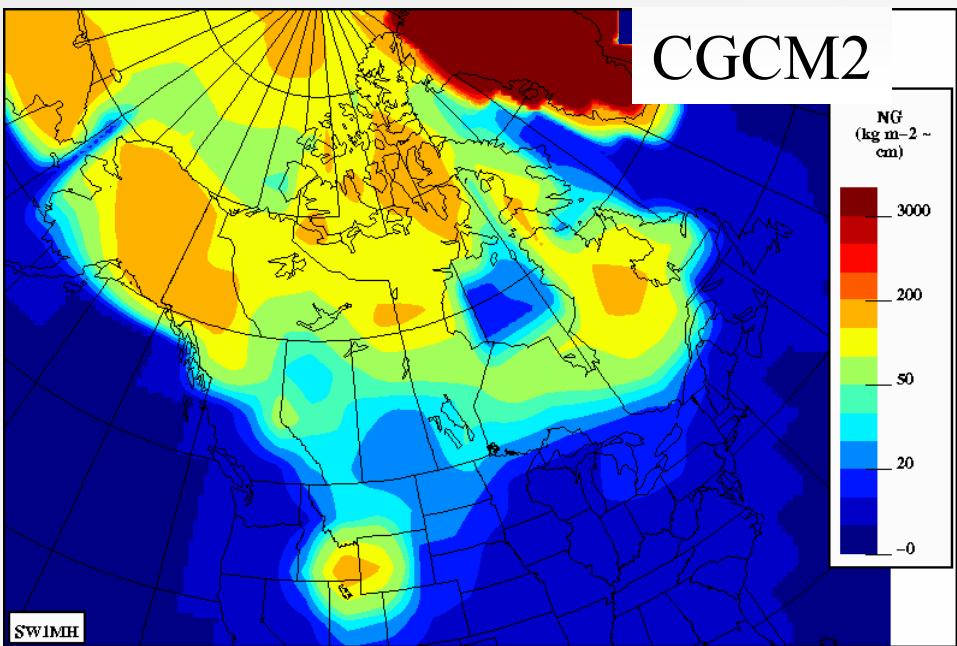
Climat actuel (1x)



Neige au sol hiver



Climat futur (2x)

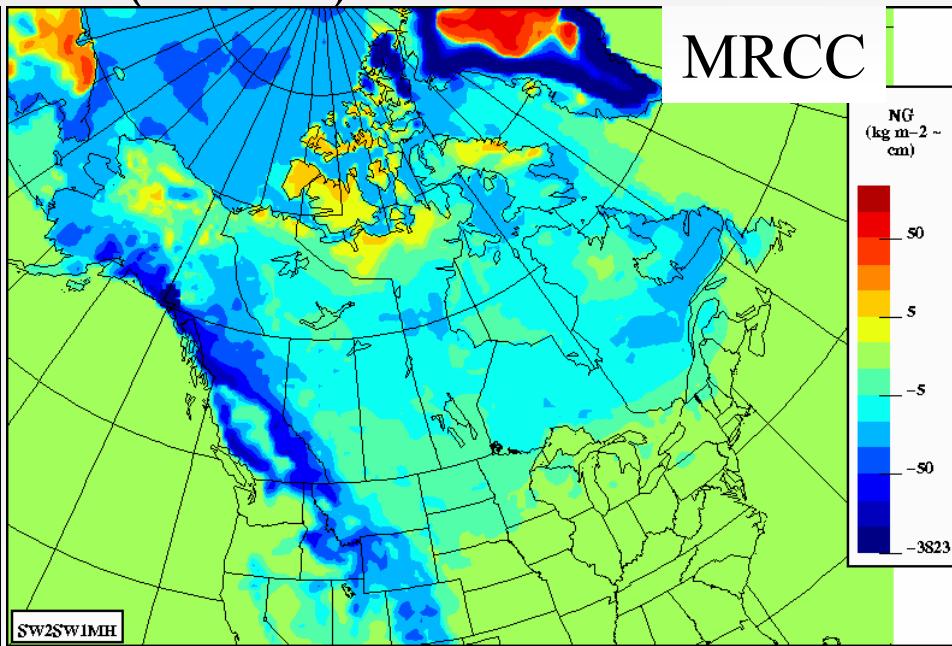
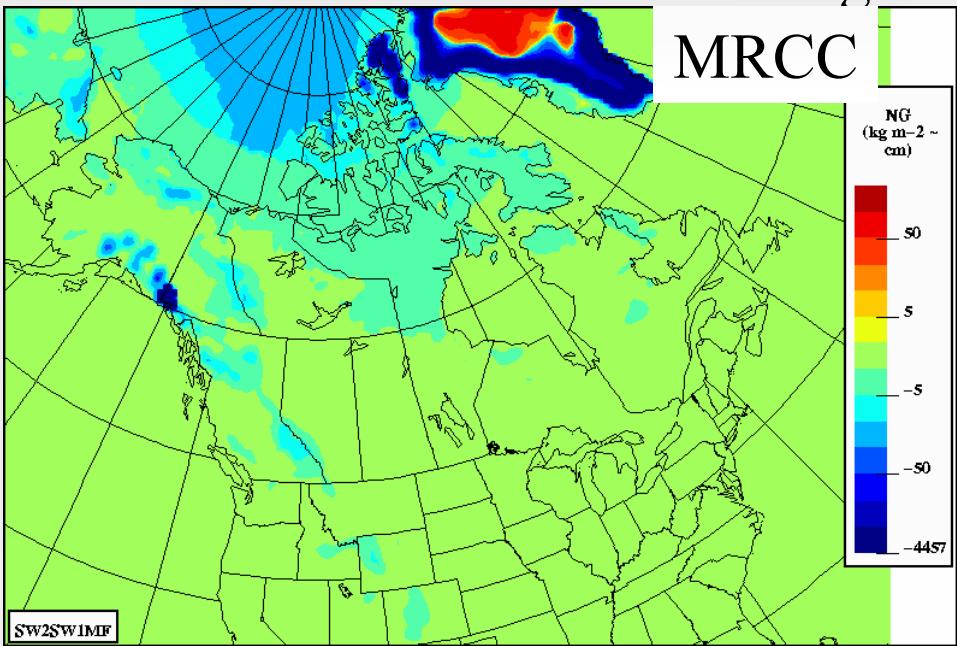


SON

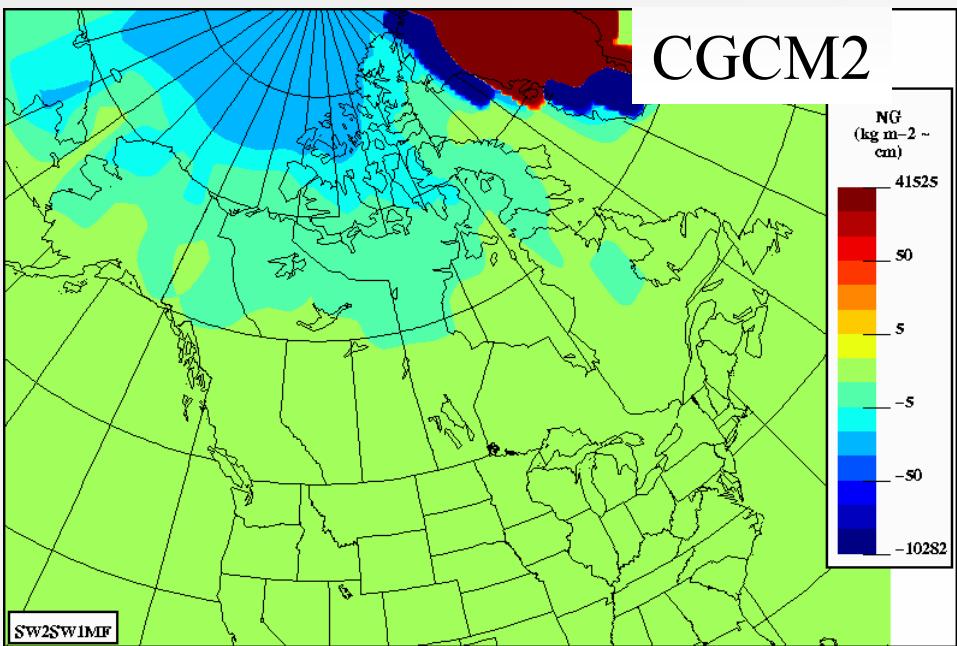
Delta neige au sol (2x - 1x)

DJF

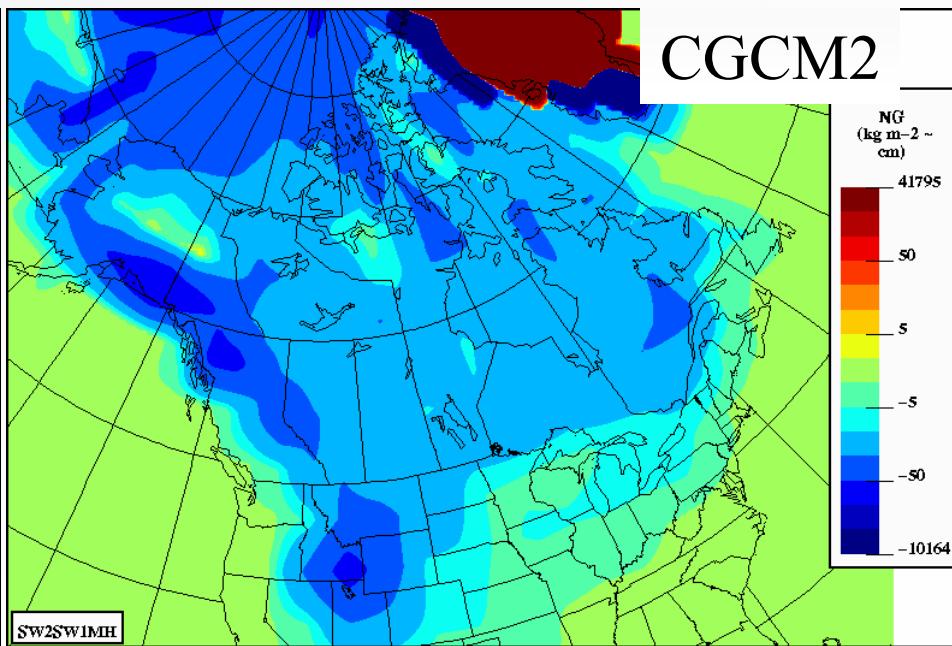
MRCC

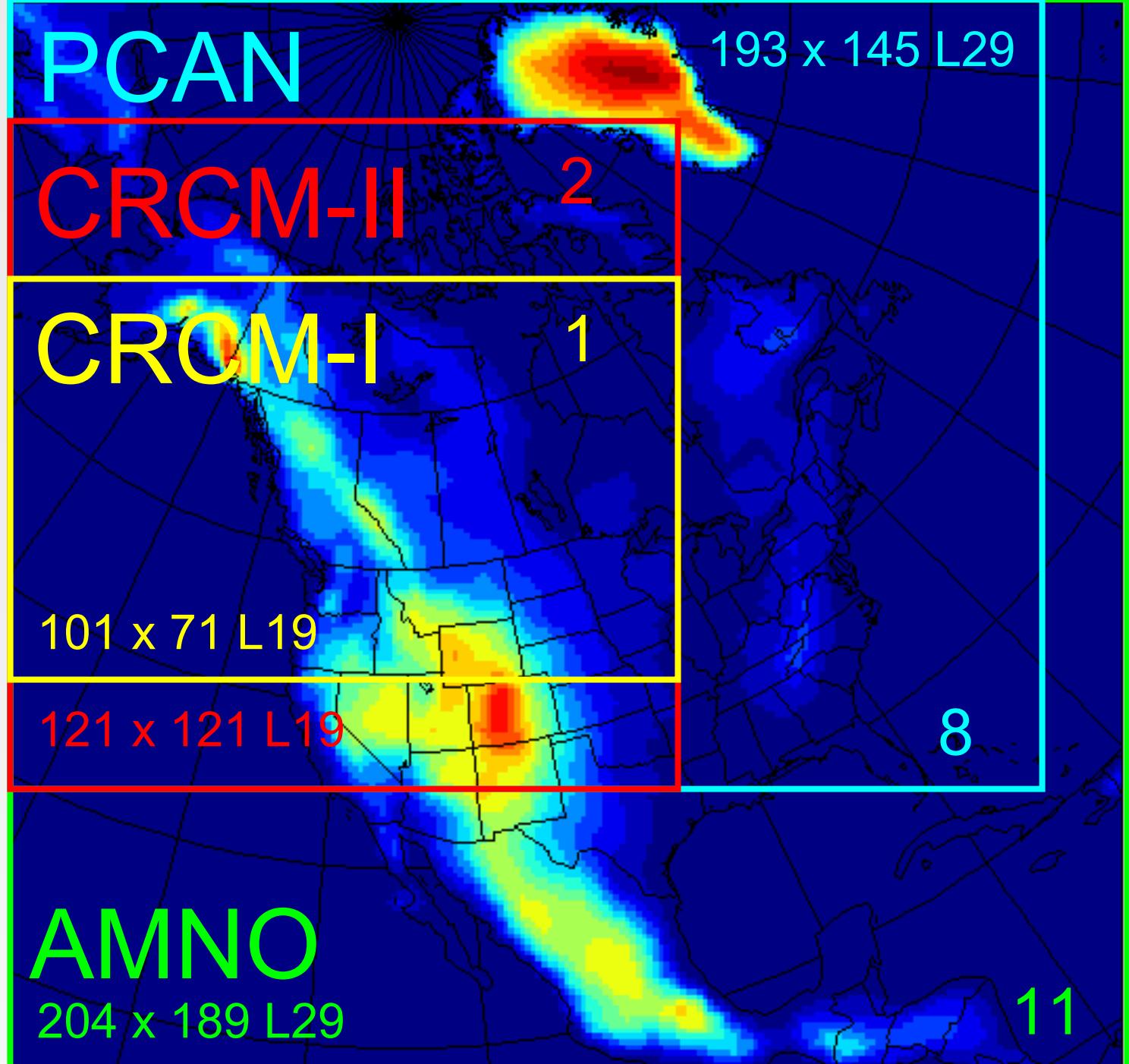


CGCM2



CGCM2



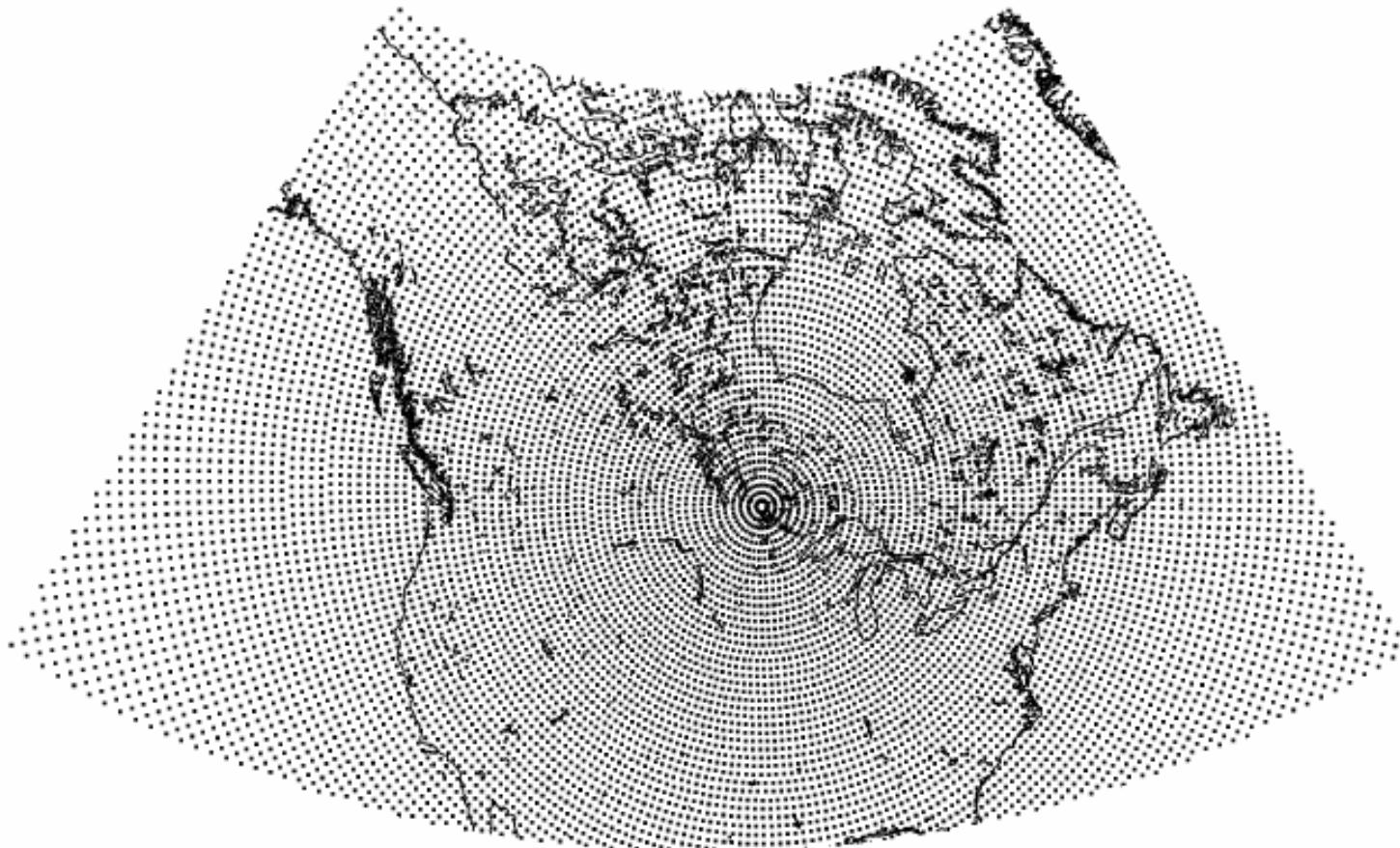


# Collaboration Ouranos - Météo-France

- Entente entre Québec et la France sur la modélisation climatique régionale
- Échange d'expertise et d'outils (modèles)
- Les modèles Arpège climat (mondial), Arpège étiré et Aladin seront installés sur les ordinateurs d'Ouranos
- Le MRCC sera utilisé sur un domaine européen permettant une comparaison avec la plupart des modèles régionaux et l'utilisation des immenses banques de données européennes disponibles pour la validation

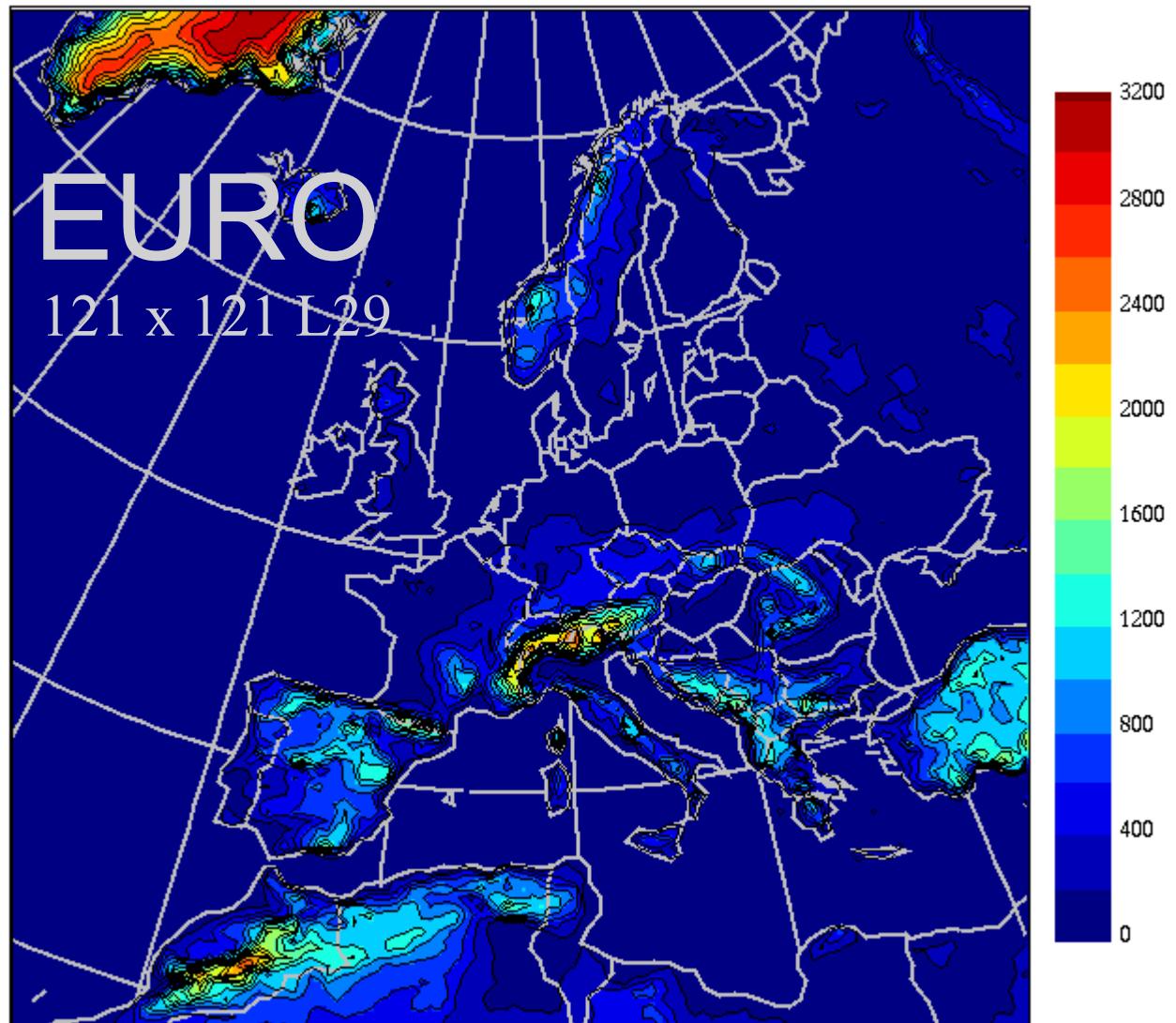
# Collaboration Météo-France

Arpège-étiré sur domaine pan-canadien



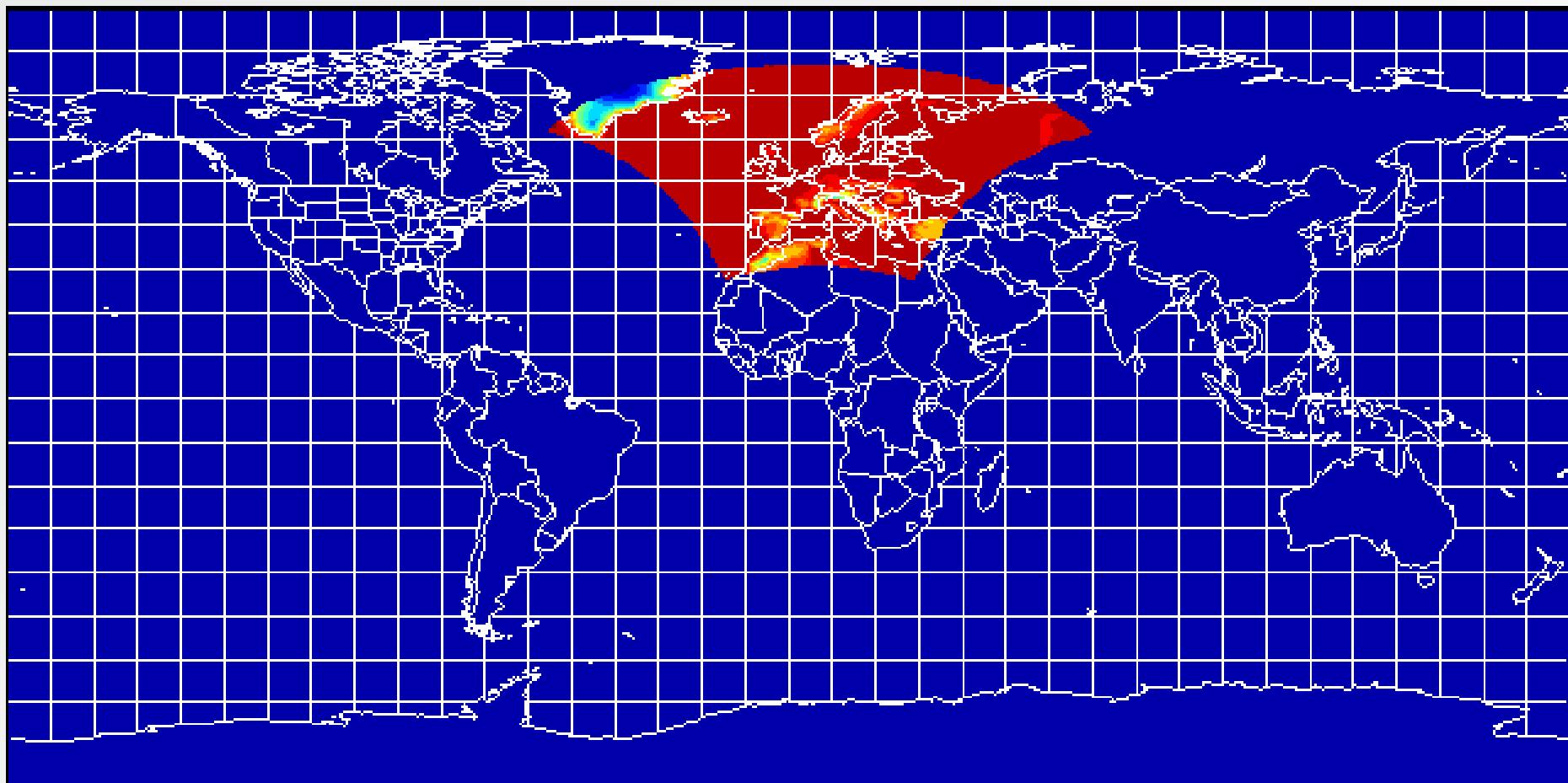
ZS (Topographie) PHIS

Niveau sigma: 1.000 - Etiquette: AVANT - Intervalle: 200 \* 1.0e+00 m



Prévision 00 heures valide 00:00Z le 01 janvier 1979

# Le domaine EURO

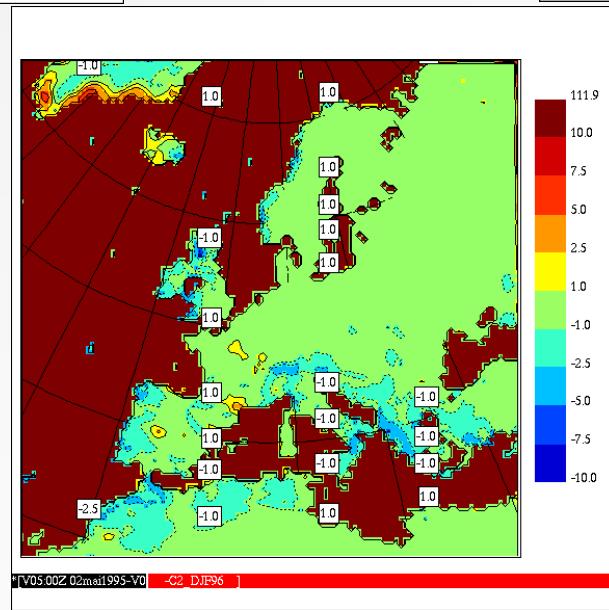
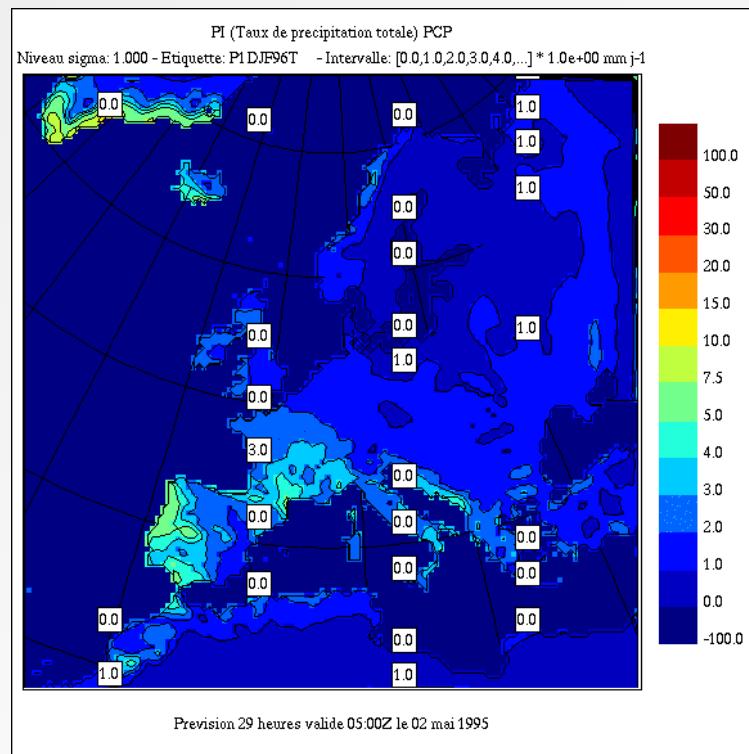
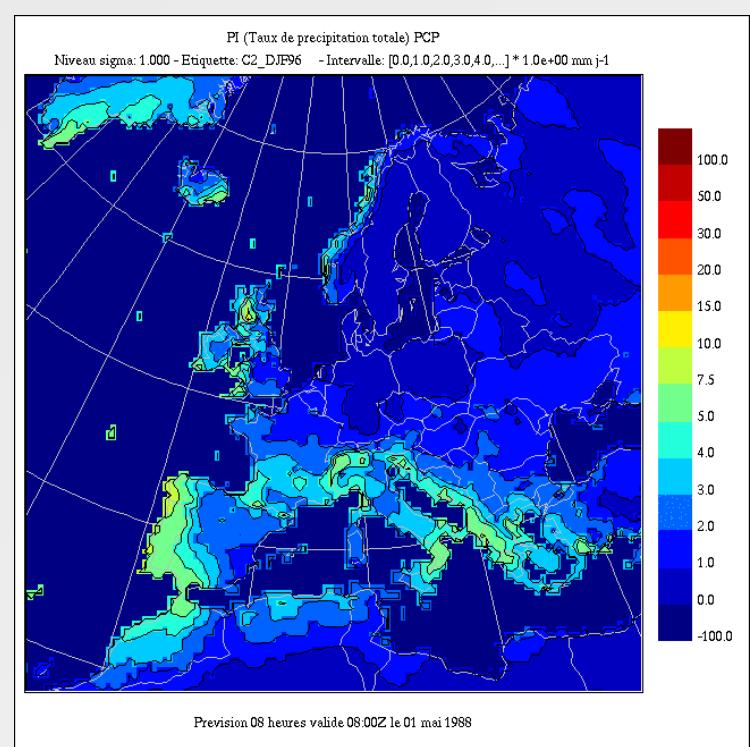


cru2

DJF 96

mrcc

pcp



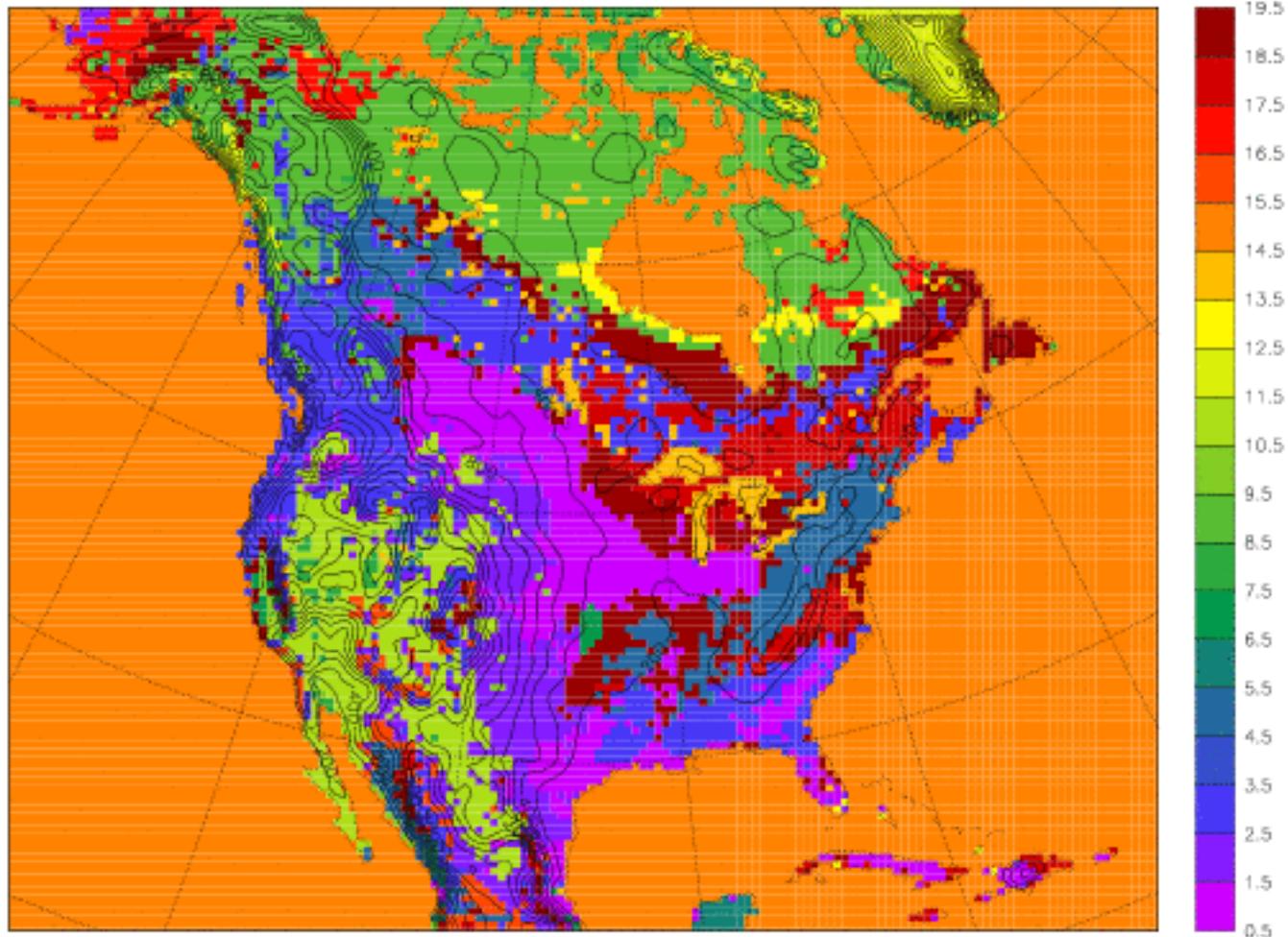
mrcc-cru2

# North American Regional Climate Change Assessment Program (NARCCAP)

- 3 or 4 GCMs to supply boundary conditions
  - NCAR-DOE CCSM; CCCma CGCM3; HadCM3 and HadAM3; GFDL AOGCM
- 5 RCMs over a North-American domain
  - CRCM; MM5; HadRM3; RegCM3; RSM
- 30-year simulations
  - control runs
  - A2-SRES scenario
- Various datasets for model evaluation
  - NCEP/DOE AMIP-II Reanalysis
  - ECMWF

# Domaine NARCCAP

GTOPO30 Topography (m) & GLCC Vegetation



NX=155 NY=130 ds=50km CLAT=47.5 CLON=-97 Mercator